HEIGHTS OF VENUSIAN STEEP-SIDED DOMES

Nathan T. Bridges and George E. McGill, Dept. of Geosciences, University of Massachusetts, Amherst, MA 01003

An apparent characteristic of many steep-sided domes (SSDs) on Venus is a very low height to width (aspect) ratio (1-4). Particularly anomalous are domes with aspect ratios of 0.001-0.01 or less, as determined from Magellan gridded topography (1) and altimetry footprint templates (3). These aspect ratios are much lower than those of steep-sided terrestrial volcanic constructs, which commonly have ratios near 0.1 (5-6). Many interpretations of SSD genesis and evolution have relied on the inclusion of morphometric data from these low domes (1,3). Here we demonstrate that most of the published heights of very-low-aspect-ratio SSD's are either 1) correct, but the domes have been geologically modified from their pristine form and originally were higher, or 2) incorrect due to difficulties in Magellan altimetry interpretation. We then show that the morphometry of SSDs is more consistent with terrestrial analogs than previously believed.

Embayment and Tectonization of Domes

To assess how much the 20 low SSDs have been modified since their formation, their degree of embayment and tectonization was evaluated using SAR images. A subjective modification scale was used, ranging from 0-3. For embayment, a value of 0 indicates that the dome interior does not appear to be embayed by regional flows or plains materials. A value of 3 characterizes domes that appear to have a significant portion of their edges and interior completely or partially covered. For tectonization, 0 indicates that the domes share virtually no structures with adjacent units whereas a dome with a value of 3 contains many linear structures that extend into the surrounding plains.

The number of domes moderately to strongly embayed is about the same as the number of ones moderately to weakly or not embayed (Table 1). The same is true for tectonized SSDs, although more domes are moderately tectonized than moderately embayed. The degree of embayment is commonly difficult to evaluate for highly tectonized domes. Similarly, evidence for tectonization can be masked where embaying flows cover linears and structures on the domes and adjacent materials. Therefore, a dome is considered to be modified if it is tectonized *or* embayed, not necessarily both. Of the 20 low SSDs, 12, or over half the group, are moderately to strongly modified (Table 1).

Interpretation of Magellan altimetry

Horizontal dimensions of Venusian domes can be accurately measured from SAR images. In contrast, published heights have relied on raw data from the Magellan radar altimeter (2-4) and on gridded topography (1). The former is preferable, because it avoids interpolation and smoothing inherent in the gridded data, which can significantly underestimate dome elevations. However, a major problem is that the size of the altimeter footprint is commonly a significant fraction of or exceeds the dome size. This hinders accurate height measurements because the flanks and edges of a dome and even the surrounding plains are integrated into the radar return. The "elevation" in this case is derived from a model template fitted to a plot of radar echo energy vs. time. If the radar return from the surrounding plains is a significant fraction of the total footprint echo, then the template is fitted to this energy peak and the elevation measured will be that of the plains, not the dome. To avoid this, the full distribution of radar echo energy as a function of time must be examined. Dome elevation can then be estimated by computing the time delay between the first and second energy peaks (corresponding to the dome and plains, respectively). Ford (4) derived maximum heights of 20 SSDs using this method and by assuming the domes had a profile of an axisymmetric Newtonian fluid (2,7). Two of these domes are examined in this study.

To improve this data set and, in so doing, better evaluate theories of dome formation, we have examined the position of altimetry footprints on 20 domes that have apparent aspect ratios of < 0.01 (3). Of the low SSDs, 11 have footprints that are a significant fraction of or exceed the dome size or are not centered on a dome. Of the 8 domes that are not strongly modified by embayment or tectonization, all but 2 have poor footprint coverage. Therefore, these 8 domes are likely higher than the altimetry indicates. In support of this, we compare two domes (ID numbers 47 and 116 of [1]) measured using elevations from footprint templates (3) and more detailed analyses of the echo energy distribution (4). Dome 47 has a height of 20 m using the first method and 801 m using the second. Values for dome 116 are 30 m and 569 m, respectively. Finally, a tectonized dome (ID# 78) was measured in stereo (8) using left-looking images from cycle 1 and right -looking images from cycle 2.

DOME HEIGHTS: N. T. Bridges and G. E. McGill

The derived height is 253 m, versus 125 m using footprint templates (3). Therefore, using footprint templates generally underestimates dome elevations, sometimes significantly.

Discussion

The two most commonly considered SSD terrestrial analogs are silicic domes (1-3) and basaltic seamounts (5,9). Silicic domes have aspect ratios somewhat greater than 0.1 (5-6). Seamounts have aspect ratios near 0.1 (10). Based on the considerations of SSD height discussed above, it seems that very few, if any, Venusian domes had aspect ratios less than 0.01 at the time of their formation. Furthermore, the high degree of modification seen on the majority of SSDs (11-12) indicates that most other domes were probably originally taller than they are today. Therefore, terrestrial steep-sided structures make better analogs to Venusian steep-sided domes than previously believed.

Table 1
Degree of Dome Modification

dome ID*	tectonization	embayment	dome ID*	tectonization	embayment
2	2	3	49	3	3
3	2	0	78	2.5	0
13	2	2	84	1	1.5
14	3	2	88	0	3
15	0	1	114	1.5	0
24	1	0	116	1	0
25	3	0	117	3	3
40	3	3	118	1.5	1
41	3	3	134	1.5	3
47	0	0	139	0	0

*dome ID is that used in (1)

References

(1) Pavri, B. et al. (1992) *J. Geophys. Res.*, **97**, 13,445-13,478. (2) McKenzie, D.P. et al. *J. Geophys. Res.*, **97**, 15,967-15,976. (3) Fink, J.H. et al. (1993) *Geophys. Res. Lett .*, **20**, 261-264. (4) Ford, P.G. (1994) *Icarus*, **112**, 204-218. (5) Bridges, N.T. (1995) *Geophys. Res. Lett .*, **22**, 2781-2784. (6) Pike, R.J. (1978) *Proc. Lunar Planet. Sci. Conf. 9th*, 3239-3273. (7) Huppert, H.E. (1982) *J. Fluid Mech.*, **121**, 43-58. (8) Plaut, J.J. (1993), in Ford, J.P. et al., *Guide to Mag. Image Int.*, p. 33-43. (9) Sakimoto, S.E.H. (1994) *Lunar Planet. Sci. Conf. XXV*, 1189-1190. (10) Smith, D.K. (1988) *Earth Plan. Sci. Lett.*, **90**, 457-466. (11) Bridges, N.T. and McGill, G.E. (1996) *Lunar Planet. Sci. Conf. XXVII*, 165-166. (12) Bulmer, M.H. and Guest, J.E. (1996), in McGuire et al., *Volc. Instab. Earth Other Plan.*, p. 349-371.